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ABSTRACT

As a result of the development of two computer statistics laboratories in the psychology department at New York's Brooklyn College, a project was undertaken to develop and implement computer program modules in undergraduate and graduate statistics courses. Rather than use the technology to merely make course presentations more exciting, the project undertook to redesign course formats entirely. The computer program modules are designed to minimize hand calculations, allowing students to spend more time mastering concepts, and to allow instructors to utilize a mastery style evaluation of the students' performance. In addition, the modules respond to students' requests for more examples by providing them with randomly generated problems and allow students to take exams as many times as they want. On-line student monitoring informs instructors of students' performance and provides students with immediate feedback on exams. Advantages of using the computer-based protocol include that it is highly flexible, gives instructors more time to provide students with individualized attention, and promotes active learning by allowing students to use the programs at their own pace and time. Disadvantages include the lack of sophistication in both generating test questions and grading and overcoming students' computer phobia. Includes sample module screen-shots. (TGI)

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Computer Aided Statistics Instruction Protocol (CASIP) Restructuring Undergraduate Statistics in Psychology An Integration of Computers Into Instruction and Evaluation

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Computer Aided Statistics Instruction Protocol (CASIP)
Restructuring Undergraduate Statistics in Psychology
An Integration of Computers into Instruction and Evaluation

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ABSTRACT

It is the authors' experience that students in introductory statistics courses tend to focus on rote calculations rather than the theories upon which statistical procedures were created. Using computer program modules to enhance lectures, the authors intend to create a class structure wherein calculations and rules could be easily obtained via computers. This permits more time for instructors to teach the underlying assumptions, characteristics and theories of each statistical test. Furthermore, through computer generated quizzing and mastery-style evaluation of student performance, the instructors can monitor class progress, and modify their teaching techniques accordingly.

INTRODUCTION

At Brooklyn College, the Psychology Department is currently in the process of setting up two Statistics laboratories for undergraduate and graduate students. The classrooms house 34 and 21 IBM PC compatibles respectively and were formed with the goal of teaching statistics more effectively and efficiently. In anticipation of the labs, we have been discussing, planning and developing a number of program modules that could be incorporated into the graduate and undergraduate courses. This paper briefly outlines the latest developments in the course designs and the program modules that we have started to use this semester. We will focus on the undergraduate statistics course because many of the following ideas were formed with the needs of undergraduate students in mind.

HISTORY

In 1993, the chairman of the Psychology department at Brooklyn College approached Ki-Young Rah and asked him to start experimenting with various ways to incorporate computers into the undergraduate statistics course. The psychology department had just received funds to set up two computer labs for the graduate and undergraduate statistics courses. Although many ideas had been proposed ranging from computerizing the lectures to virtual classrooms, they could not be tested nor improved due to the limited resources available at the time.

Rah decided to take a conservative approach by taking into account the limited student access to computers at the time. First, computer assignments using a spreadsheet program were utilized as extra-credit assignments. These assignments gave the students hands-on experience with various statistical theories. Second, because of the constant request for more examples, a program was written which randomly generated problems with data and answers. Finally, the students were given access to a freeware tutorial which was downloaded from the Internet. Overall, the students were very receptive to these additions.

Two years later, with the impending completion of the statistics labs, the authors sat down to discuss how computers could be used to enhance undergraduate statistics courses given the increased student access to computers.

PHILOSOPHY

When we began to discuss how to take full advantage of the new facilities, we decided to shift our focus from using technology as a mere enhancement of lectures to restructuring the course itself. Enhancing lectures, especially for a dry subject matter such as statistics, can be of great value. Points can be illustrated with color graphs, animation, video and sound. Such enhancements may draw the student's attention and increase the

likelihood that the point will be remembered. Unfortunately, such multimedia presentations still have the same inherent flaw as any form of lecturing. It is extraordinarily difficult to pace and present lectures that will satisfy all of the students. Any lecture format always results in some students becoming very bored, and others completely lost.

In addition, using technology introduces two additional problems. First, the presentation may effectively entertain the students, but it may also serve to divert their attention. That is, they may miss the vital information that is given within the presentation. Second, by using video clips, slides and sound, flexibility is limited. One of the main reasons why blackboards are still used today is simply because they provide the greatest flexibility. It is difficult to edit a video clip or reshuffle the order of a computer slide show during a lecture. Furthermore, it is difficult to justify the amount of time taken to develop a multimedia presentation when conventional lecturing style could basically get the same points across, although perhaps in a less entertaining way.

Taking note of such problems, we decided to shift our focus from presenting a more exciting, dynamic presentation to changing the format of the course itself. We began by defining our goals. What do we, as instructors, want the students to take away from the course? Our main goal, even when using conventional lecturing styles, has always been to teach students how to organize, analyze and interpret data accurately. To achieve this goal, the students need to: 1) know how and when to use various statistical techniques, 2) understand the theories behind the techniques and 3) develop a "number sense".

Our experience has been that students tend to focus more on rote calculations and following steps rather than on the underlying theories of the statistical techniques. In other words, the students gained "declarative" rather than "procedural" knowledge.

Many students come into the course dreading the next few months because of their fears of mathematics. They know that, in a typical professional setting, statistical analyses are mostly done with the help of computers. They argue that there is little need to know the formulas to correctly analyze data.

Although this may be the case, many may argue that one loses some understanding of statistics when analyzing data strictly with computer assistance. We agree with this concern. Doing calculations by hand seems to better promote understanding of the mathematical bases for statistical tests. Students are better able to grasp the notion that a variance refers to "an average squared deviation from the mean" if they perform the calculations by hand. In addition, by performing enough calculations, they are able to estimate what the test statistic should look like by examining the data. This ability to predict what the final outcome should look like is what we refer to as "number sense." It is a very important ability because it allows the student to more accurately interpret results from a statistical package by performing error checking. As such, we have chosen to greatly de-emphasized the hand-calculation component of the course.

With our goals in mind, we next focused on the immediate needs of the students. Every semester, a number of students make the same requests: more examples, more chances to prove comprehension of the material, and access to tutors. We endeavored to meet the first request by allowing the students to generate their own examples and calculations. For the second request, we decided to redesign the course to allow the students to take the final exam as many times as they wished. For the third request, the course was redesigned to be much more student oriented.

INSTRUCTION

At Brooklyn College, we are allotted three hours of lecture and four hours of laboratory time per week. As our course design stands now, we use the first month or two to lecture to the students. The laboratory time is used to teach the students how to use the computers and our software modules. After the lecturing has been completed, the lecture and laboratory time is combined to form one large class. This is the time period within which the students may practice, test their knowledge, or take exams at their own leisure. The instructors spend this time giving individualized assistance to the students when needed. This format was conceived to maximize the individualized help that we wished to achieve.

The students are given access to a number of programs that provide examples, explanations and the ability to explore theoretical issues. EXPSTAT generates random studies, data and answers. The students may generate a random example and test themselves on the calculations or design topics. Similarly, the instructor can use EXPSTAT to clarify lectures through examples. A number of tutorials on various theoretical topics are also available for the students to go through on their own time. This allows students to review topics interactively at a pace with which they are comfortable. Lastly, a set of spreadsheet pages (QPWstat) were created that

provide analyses and graphs. These spreadsheet pages are used to illustrate various theoretical issues. This is achieved during lectures where immediate changes in graphs and test results can be pointed out as different types of data are entered. The spreadsheet pages are also used for assignments which allows us to direct the exploration process and emphasize the important theoretical concepts. For example, the idea of a Type II error can be elucidated by having the students randomly select two samples from two different populations. The students are then instructed to test whether the two samples differ significantly. By considering whether the observed result conforms to the expected outcome, the students are provided with a concrete example of Type II error.

When designing the above mentioned programs we had to consider their ease of use. We were also careful to create an interface that was consistent and simple to learn. We opted to use the Microsoft Windows™ due to its GUI interface and the simplicity of its "point and click" operations. The program that brings the above mentioned programs into a single package is called SKRstat (see Fig. 1).

MASTERY-STYLE EVALUATION

In our experience at Brooklyn College, students who enroll in an undergraduate introductory statistics course tend to vary enormously in their educational backgrounds and interests. Furthermore, because we typically teach the evening section of the course, there is also a wide age range.

We believe the mastery style is the most effective and accurate method of evaluating a student's knowledge of statistics. By allowing the students to take the final exam multiple times, we minimize the effects of various extraneous factors. Unfortunately, applying a mastery format dramatically increases the amount of work for the instructor and teaching assistant. However, if we make use of computers to generate random exams (or randomly select exams from a database) and grade them, then no extra work would be added. In fact, the evaluation would be much simpler and would require less effort.

We have developed such a program, called SKRquiz (see Figure 2). The program uses the same user interface as SKRstat so that student expertise in using the program does not impact their grade. SKRquiz can present two types of questions. First, theoretical topics and simple calculation questions are asked in a multiple choice format. The program randomly selects a set number of multiple choice questions from a question bank written in text format and presents them.

Second, experimental design questions and calculations are tested using the previously mentioned example generation engine (EXPSTAT). Various questions about the study design are asked, such as tail, hypotheses, and statistical test to be used. Then, the calculation screen is displayed in the same way as shown in SKRstat. However, instead of presenting the students with the completed calculation steps, the students are required to fill in randomly selected missing values.

The exams are timed and the program provides immediate feedback on how the students are doing and allows them to review their answers. They are also given the opportunity to review any past exams and print them to study from as needed. This allows the students to learn from their own mistakes. Before taking the final exam, the students are encouraged to take practice quizzes to familiarize themselves with the format and difficulty of the questions. Only their best final exam score is used (and other assignment grades) when determining their course grade. We believe that this will motivate the students to learn beyond the minimum necessary to do well in the course.

ON-LINE STUDENT MONITORING

The use of computers for teaching and evaluating provides a very convenient way to monitor a student's performance. The use of these various programs and exams are all logged for each student. This informs the instructors in which areas students have the most problems and whether the exams were too easy or difficult. This design also gives early warnings of students who are performing very poorly but are hesitant to approach the instructors for assistance or guidance.

The students are also able to monitor their own performances. The computer provides immediate feedback on the exams and allows for later review. Also, through the use of SKRstat, the students are able to recognize their areas of weakness. Through this self-monitoring the students are constantly aware of their progress.

ADVANTAGES/DISADVANTAGES

Advantages

There are a number of advantages to using a computer based protocol. First, the instructor spends less time formulating questions and calculating answers. We have found that one of the most frustrating limitations in lecturing is the amount

of time spent doing calculations and drawing graphs. It would be much more efficient and effective to use a computer to do the calculations and draw the graphs both during lectures and during the lab section when the students are generating their own examples. This frees up the instructor's time to focus on more theoretical topics and answer individualized questions during the lab section. Also, the chance of making an error is decreased by having the computer do the calculations.

The same advantage is found for the evaluation process. A mastery-style evaluation protocol is possible only because the computer is able to effortlessly generate as many exams as needed. The time needed by the instructor and/or teaching assistant to generate and grade the same number of exams is unrealistic.

Second, the student can use these programs to study at their own pace, on their own time. Thus the student takes an active role in the learning process. This individualized learning allows both the strong and weak students to learn at their own pace without affecting other students. Similarly, the exams are taken at the convenience of the students and as often as they wish. Therefore, their grades will not be so strongly affected by various personal problems that may arise throughout the semester, such as illnesses, religious commitments, etc. The students are also less anxious about taking the exams because they know that there will be other opportunities to show their true levels of knowledge. Also, the constant feedback as to how the students are doing, serves to motivate them to study.

Finally, the current design is highly flexible. Feedback from students' performances allows the instructor to optimize the type of exams given. Furthermore, the program modules can be implemented in a variety of different course designs and lecture formats. Depending on how the students use the various available programs, one can implement different levels of computerization.

Disadvantages

The main disadvantage to using computer generated exams is the lack of sophistication in both the generation and grading. The multiple choice questions can be as complex and theory oriented as possible because they are generated by the instructor. However, the study related questions are very structured and limited in many ways. Free-form calculation, making interpretations and answering questions in either essay or short answer format is not currently possible. Also, by allowing the students to take the exams multiple times, we run the risk of the students memorizing the correct answers to the multiple choice questions. This is a major problem that can only be minimized by increasing the size of the multiple choice question database. The same lack of sophistication is present in tutorials. A tutorial can never be written that will cover all the questions that students will ask. That is why human instruction is still necessary.

A second disadvantage is computer phobia. Students who have never touched a computer before may perform poorly on exams and assignments partly because of their discomfort with using computers. We have tried to minimize this by urging the students to use the various programs and take practice quizzes as soon as possible, but there may still be students who remain uncomfortable using a computer.

Lastly, some may argue that using computers as teaching assistants takes away the interactivity between the student and instructor and between the students themselves. This loss of interactivity would probably be a serious disadvantage if computers take over the role of the lecturer. However, CASIP was specifically designed to maximize this human interactivity between instructor and student rather than reduce it.

CURRENT OBSERVATIONS

The Spring 1996 semester marks the first semester within which we have implemented our course design. Although the course has only been underway for about one month, we have noted some successes with our format. Within one month's time we have noted that the students have an increased comfort with the computers and the program modules. Furthermore, the students have expressed an increased interest in the subject material due to the highly interactive nature of the assignments and tutorials. We have also noticed that the students were spontaneously forming small groups in the form of collaborative learning. It would seem that having a common enemy (the computer) does tend to bring people together. We also noticed that there were many students who preferred to work alone. We believe that this option to work alone or together is an improvement over the formalized collaborative learning paradigm.

There have been, as well, some pitfalls. For example, the students have been somewhat bewildered by the amount of information that is presented in the first month. They sometimes have trouble grasping the concepts, and other times complain that the lecture moves too fast. This is understandable because we have designed the course such that they would receive all the

theoretical and basic concepts in the first month or so. The reasoning behind this format was to maximize the individualized instruction time that the students would receive once the lecturing section of the semester is over. However, we have been persuaded by the students to extend the lecture time this semester, and we will be considering alternative organizations for the lectured material.

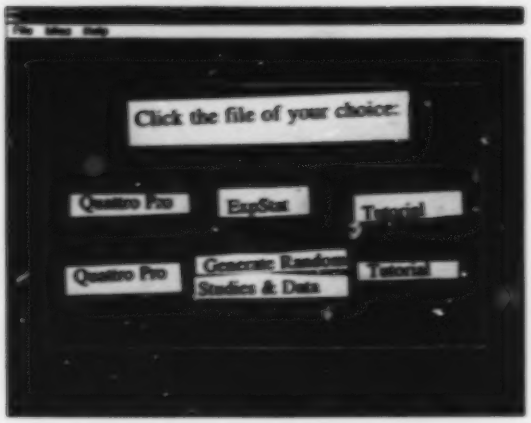
The use of computers introduced a number of problems that we had not foreseen. Security for assignments and exams is a major consideration. Although, the student must sign in with a user id and password, it is not very difficult to copy or modify key files that determine their grades. In response to this new threat, stringent security measures were devised. Each of the students' disks are collected at the end of every class and backed up on the instructor's machine. The students are also restricted from doing the assignments and taking the exams outside of the classroom. Lastly, the students will be required to sign in when they decide to take the final exam.

Another problem with computer use is accidentally deleting or overwriting files. A number of students have already managed to overwrite previous assignments that had been completed. The frustration is understandable and very difficult to rectify. Again, we hope that enough experience with computers will limit the number of such disasters.

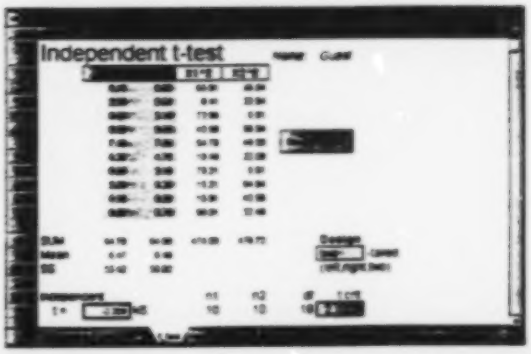
Because this is the first semester in which we have presented this format of teaching statistics, we did not expect it to be flaw-free. However, because our computer modules have been set up for maximal flexibility, we hope that we can correct any major flaws in the design for future semesters.

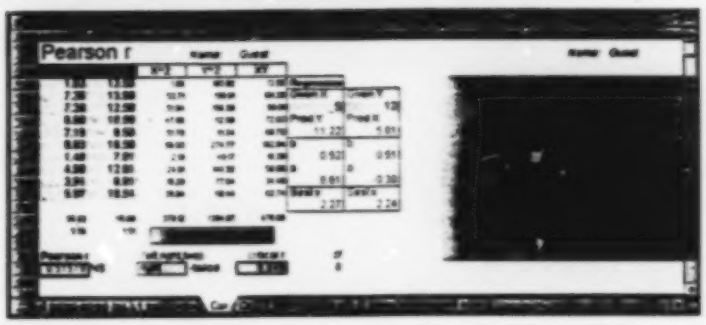
World Wide Web Page:
http://acc6.its.brooklyn.cuny.edu/~krah

SKRstat

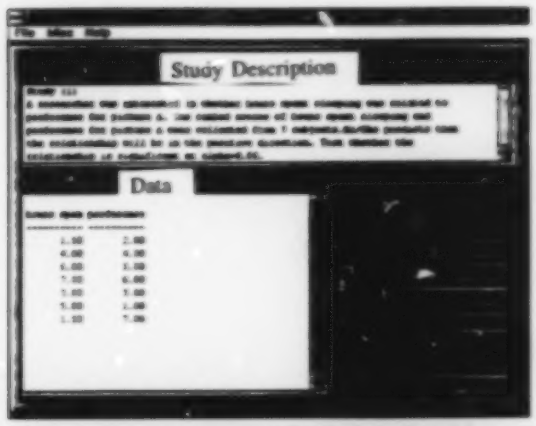


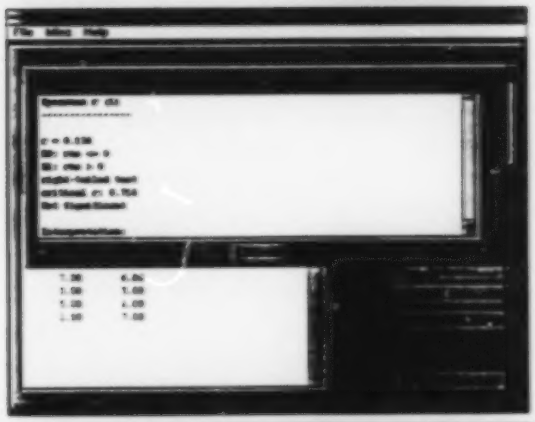
QPWstat





EXPSTAT





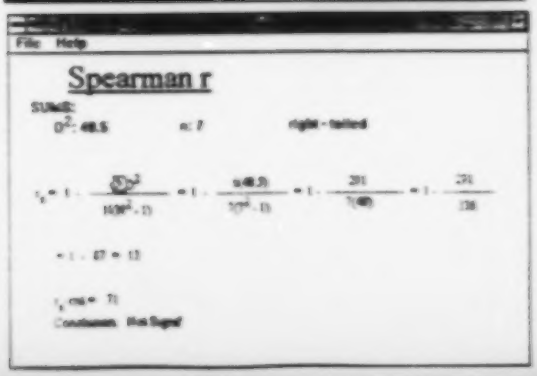


Figure 2

SKRquiz